Evaluation of a Tactical Surface Metering Tool for Charlotte Douglas International Airport via Human-in-the-Loop Simulation

DASC
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Savvy Verma, Hanbong Lee, Vicki Dulchinos, Lynne Martin, Lindsay Stevens, Yoon Jung, Eric Chevalley, Kim Jobe & Bonny Parke
• Background
  – The Challenge
  – Previous Research
  – ATD-2’s Metering Tool
• Objectives of Study
• Tactical Surface Metering Tool
• Experiment Details
• Results
• Summary
The Challenge

Surface Congestion

Long Runway Queue

Loss of Predictability

Will Departure/Surface Metering help?
• Strategic Metering Tool at JFK (Stroiney et. al. 2013)
  – Schedules provided two hours in advance
  – Taxi out benefits ranged from 1.5 to 2.7 min per flight
• Spot and Runway Departure Advisor (SARDA) (Jung, Malik, Gupta & Hayashi, 2014)
  – Tactical in nature, schedules for the next 15 min
  – Benefits to taxi times were shown for both DFW and CLT
  – SARDA did not use ready times or Earliest Off Block Times (EOBT) or Ration By Schedule (RBS) principles for creating schedules

Need a tactical metering tool that can be extended to include strategic scheduling
ATD-2’s Metering Tool

• Does not control capacity, just estimates it
• Provides advisories that throttle demand to the runway during surface metering
  – Earliest off block times are used to estimate demand at any given time.
  – The tool does not double delay flights subject to FAA restrictions
  – Orders flights based on their accuracy of EOBTs, Priority, FAA restrictions, exempted flights
• Provides pushback advisories based on calculated Target Off Block Times (TOBT)

ATD-2 = Airspace Technology Demonstration-2
Objective of the Study

• Evaluate the Metering tool that provides recommended gate hold times or pushback advisories based on the formula:
  \[ \text{TOBT} = \max \{ \text{EOBT} , \, \text{TTOT} - \text{UTT} - \text{Metering Value} \} \]

• Evaluate the Metering Value that is agreeable to both Airline Ramp and the ATC-Tower
  – Metering value is a buffer or excess queue time that could be taken at the gate or as taxi delay

EOBT= Earliest Off Block Time
TOBT= Target Off Block Time
TTOT = Target Take Off Time
UTT= Unobstructed Taxi Time
Tactical Surface Metering Concept

- Spot Release Advisories
- Gate Pushback Advisories
- Data Exchange & Integration
- Efficient Runway Schedule

Surface Modeler → Runway Scheduler → Spot Advisor → Gate Advisor

Surveillance → EOBT → Arrivals Demand → ATC Intent → Unobstructed Runway Times → Runway Times → Metered Spot Times → Metered Pushback Times

EOBT – Earliest OFF Block Times, RBS= Ration By Schedule
 Metering Tool Advisories on User Interface

- **Push advisory**
  - EOBT < 10 min

- **Gate Hold Advisory**
  - EOBT < 10 min

- **Hashtag: Click here to get an advisory**
  - EOBT > 10 min
Experiment Details

• Experimental Matrix
• Scenario
• Participants
• Tools and Equipment
### Experiment Matrix

- **Two variables:**
  - Metering Value / Level of Hold (3 levels)
  - Airport Configuration (2 levels)
  - 3 x 2 matrix

<table>
<thead>
<tr>
<th>Metering Value</th>
<th>Runway Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>North</td>
</tr>
<tr>
<td>8 min</td>
<td>N_8</td>
</tr>
<tr>
<td>10 min</td>
<td>N_10</td>
</tr>
<tr>
<td>12 min</td>
<td>N_12</td>
</tr>
</tbody>
</table>
Airport Map - Charlotte Douglas International
• South Dual Converging Operation
  – 92 arrivals & 80 departure per hour
• Triple North Operation
  – 75 arrivals & 65 departures per hour
• No wind, clear visibility, but IFR rules in effect
• No General Aviation flights
• No Cargo flights
• Duration 60 min
Participants

- Four Ramp Controllers – two active and two retired controllers
- One Ramp Manager
- Five Pseudo pilots as confederates
Tools & Equipment

- Ramp Control Tower to emulate Charlotte
  - 360 degree Simulator at Future Flight Central (FFC)
  - Ramp Traffic Console (RTC) & Ramp Manager Traffic Console (RMTC)
Ramp Traffic Console
Results

- Gate Hold Time
- Acceptability of Gate Hold Times
- Taxi Out Time
- Taxi In Time
- Queue in Airport Movement Area
- Run Durations
- Workload
- Situational Awareness
- Acceptability of departure queue
- Acceptability of departure demand
Gate Hold Time

- South Flow Gate holds decrease as metering value increases
- North Flow is possibly impacted by short run duration
- Compliance to gate hold times is within 1 min

Results

<table>
<thead>
<tr>
<th></th>
<th>N_8</th>
<th>N_10</th>
<th>N_12</th>
<th>S_8</th>
<th>S_10</th>
<th>S_12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time difference (min)</td>
<td>Gate Hold</td>
<td>Compliance to TOBT</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N_8</td>
<td><img src="image" alt="Bar Graph" /></td>
<td><img src="image" alt="Bar Graph" /></td>
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<tr>
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<td><img src="image" alt="Bar Graph" /></td>
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<tr>
<td>S_10</td>
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<tr>
<td>S_12</td>
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<td><img src="image" alt="Bar Graph" /></td>
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<td></td>
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</tr>
</tbody>
</table>
Acceptability of Gate Hold Times

Gate hold times were reported as “just right” by the participants.
Queue in Movement Area

North Flow Queue in Movement Area

- South Flow responds to different Metering values
- North Flow is not as responsive

South Flow Queue in Movement Area
## Run Duration

<table>
<thead>
<tr>
<th>Run name</th>
<th>Runway Configuration</th>
<th>Metering value (min)</th>
<th>Run duration (min)</th>
<th>Departure number (OFF)</th>
<th>Arrival number (IN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N_8</td>
<td>North flow</td>
<td>8</td>
<td>66.3</td>
<td>44</td>
<td>38</td>
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<tr>
<td>N_10</td>
<td></td>
<td>10</td>
<td><strong>50.2</strong></td>
<td>27</td>
<td>26</td>
</tr>
<tr>
<td>N_12</td>
<td></td>
<td>12</td>
<td>67.2</td>
<td>54</td>
<td>50</td>
</tr>
<tr>
<td>S_8</td>
<td>South</td>
<td>8</td>
<td>53.4</td>
<td>42</td>
<td>28</td>
</tr>
<tr>
<td>S_10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S_12</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

*Gate Hold and Taxi Time increases with increase in run duration more so in North Flow than South Flow*

![Graph showing GateholdT, North and Taxi-outT, North](image)

**Results**
Workload was not significantly impacted by changes in the metering value
The departure demand was reported as acceptable by both Ramp and ATC-T for metering value of 12.
Summary

• Metering value affects Gate Hold Time and Queue Size as expected
• Gate Hold Times were reported as ”just right”
• Metering value of 12 reported as not drying up the runway or seen as creating long queues
• Metering value of 12 planned to be used as the nominal value for metering tool when deployed in the field
Thanks for your attention!

Savita.a.verma@nasa.gov
Backup slides
Throughput in North

Accumulated takeoffs - North flow

Takeoffs (ac) vs Simulation time (minute)

- N_8
- N_10
- N_12
Throughput in South

Accumulated takeoffs - South flow

Takeoffs (ac)

Simulation time (minute)

S_8  S_10  S_12
Level of Holds is based on Metering Value and is a balance between gate holds and runway queue size.
Tactical Surface Metering Concept

- Estimates capacity of current and future runway resources
- Builds an efficient runway schedule based on readiness, EOBT and RBS
- Calculates spot advisories that support the metered runway schedule
- Provides push back advisories from gates that support the spot advisories

**Surface Modeler**

**EOBT**

**Arrival Demand**

**ATC Intent**

**Runway Scheduler**

**Unobstructed Runway Times**

**Runway Times**

**Spot Advisor**

**Metered Spot Times**

**Gate Advisor**

**Metered Pushback Times**

**Data Exchange & Integration**

**Gate Pushback Advisories**

**Spot Release Advisories**

EOBT – Earliest OFF Block Times, RBS= Ration By Schedule
ATD-2’s Metering Tool

Data Exchange & Integration
- Integrated Arrival/Departure/Surface (IADS)
- Onramp to the overhead stream
- New data elements shared between FAA & Industry
- Real-time metrics for planning and awareness

Surface modeling, scheduling & metering
- Surface modeling based on heuristics and trajectory based model of airport operations
- Use of Earliest Off Block Times (EOBT) for the purpose of Scheduling
- **Surface Metering** based on demand and capacity imbalances, tactical in nature initially
ATD-2 Users
<table>
<thead>
<tr>
<th>Group</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncertain</td>
<td>Flights with poor quality EOBT OR EOBT – current time &gt; 10 min</td>
</tr>
<tr>
<td>Planning</td>
<td>Flights within 10 min of EOBT (i.e., EOBT – current time &lt;= 10 min)</td>
</tr>
<tr>
<td>Ready</td>
<td>Flights that have called in ready for pushback</td>
</tr>
<tr>
<td>Out</td>
<td>Flights that are in pushback state</td>
</tr>
<tr>
<td>Taxi</td>
<td>Flights that are cleared for taxi</td>
</tr>
<tr>
<td>Queue</td>
<td>Flights waiting in the runway queue</td>
</tr>
</tbody>
</table>